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ABSTRACT

De Anza College's Institute for Computer-Aided Mathematics Instruction (ICAMI) is a direct outgrowth of the computer-aided mathematics program, in California, started at the California college in 1982. ICAMI focuses on the design and dissemination of effective instructional models for: (1) skill building for more efficient problem solving, focusing on mastering pre-, beginning, and intermediate algebra skills; (2) exploration of mathematical concepts such as limits, differentiation, and integration at the pre-calculus and calculus levels; and (3) simulation and stochastic processes. In the summers of 1988 and 1989, ICAMI conducted three 6-week programs focusing on these models, each accommodating between 10 and 34 participants. The program entitled "Basic Skills in Problem Solving" was designed to help teachers of pre-, beginning, and intermediate algebra to develop a plan to implement computer-aided instruction in their classes and to select a large number of problems, matched with course curriculum and categorized into problem-solving strategies. The program entitled "Teacher-in-Service: Exploratory Model" helped instructors develop a curriculum for the 1989-90 school year that employed the numerical and graphical strengths of the computer to teach mathematical concepts from algebra through calculus. The third program, entitled "Interactive Statistics with Probability," was designed to introduce junior and senior high school teachers to simulation, graphics, and computer-driven interactive activities. Course outlines are provided for each of the summer institutes. (AYC)

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A Report from

ICAMI

The Institute for Computer-Aided Mathematics Instruction

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The Institute for Computer-Aided Mathematics Instruction (ICAMI)

I. INTRODUCTION

ICAMI is a direct outgrowth of the computer-aided mathematics program started at De Anza College in 1982. The De Anza program grew out of the realization that computers are changing the way we think, practice, learn, and teach mathematics. Computers allow for the modeling of mathematical situations previously beyond the reach of most students and instructors. It reaches beyond human calculation and facilitates the exploration of mathematical ideas considered intractable or impractical. It is precisely this compelling power and increasing accessibility of the computer that is challenging the more traditional approaches in mathematics education.

The creation effort on the part of the De Anza team (Chris Avery, Chris Barker, Frank Soler) focused on the design of instructional models which would effectively use computers to provide access to mathematical concepts. Three pedagogical models were designed and classroom tested in De Anza College's mathematics department 40 station computer lab.

Many schools expressed an immediate interest in these models. Due to this interest, a pilot institute was started in summer 1986 subsidized by grants from TECC/8 for $3000, from De Anza College for $1500 and a donation from Apple Computer Inc of 10 Apple //e computers. Forty teachers attended the first Institute spending between one and six weeks at De Anza College. As a result of the 1986 Institute, additional local programs were started.

In 1987, under the leadership of Susan Talbot, Evergreen Valley College joined with De Anza College to present the second pilot Institute. Susan Talbot was a graduate of the 1986 Institute and had implemented a computer-aided program at Evergreen. The 1987 Institute saw the addition of six more schools to the growing list of local schools adapting these models to their needs.

II. COMPUTER-ASSISTED INSTRUCTIONAL MODELS

The De Anza program in CAI in mathematics centers around three instructional models: skill building for more efficient problem solving; exploratory; and simulation.

The **problem solving model/skill building** focuses on mastering identified skills corresponding to time honored topics in Pre, Beginning, and Intermediate Algebra. The student masters these skills by working randomly generated problems at three levels of difficulty. When mistakes are made, appropriate hints are given to assist the student. Scores are recorded on disk for student and teacher reference. With this model, students are able to master skills in a shorter period of time. This allows for increased classroom time devoted to the application of these skills in related problem solving situations. The lab component promotes an interactive and dynamic learning environment where individualization and mastery learning are the rule rather than the exception.

The **exploratory model** allows students to go far beyond algebraic processes. The student is immersed in exploring mathematics at the Pre-Calculus (Trigonometry, Analytic Geometry, College Algebra) and Calculus levels. Concepts such as limits, differentiation, and integration are numerically and graphically performed at the touch of a key. The student focuses on the correct approach to a problem. The underlying principles of a problem take precedence over algebraic procedures. A series of laboratory assignments has been carefully prepared to provide a foundation from which the student may experience complex mathematical ideas in a graphic, numerical, and intuitive setting. Algebraic procedures are used to frame problems and to verify numerical results. As such, they become more meaningful than standard textbook exercises. Instructors are encourage to use the computer in the classroom as part of the lecture presentation. This opens up new avenues of investigation centered around "what if". The student has immediate and equal access to concepts and processes previously "owned" solely by the instructor.

The **simulation model** addresses stochastic processes by providing the student with the ability to sample from a variety of distributions, analyze data via a variety of graphical and numerical statistical techniques, and make decisions based on probabilistic results of such analysis. Thus, theoretical and empirical results are constantly compared and contrasted. Dramatic demonstrations of difficult statistical results (eg. graphical relationships among different distributions; live simulations of the Central Limit Theorem) are the norm. This experience is totally different from the traditional deterministic, formula oriented approach so commonly found in the typical statistics classroom. It is imperative for the instructor to incorporate use of the computer into the lecture presentation. Appropriate materials have been developed (textbook and laboratory assignments) and tested at De Anza and participating pilot schools.

III. The 1988 Institute

The Institute at De Anza College and Evergreen Valley College received a $350,000 grant

from the California Postsecondary Education Commission for 1988-89 and 1989-90. Apple Computer Inc. also contributed a desk-top publishing system. With this support, three six-week programs were started on June 27, 1988.

The **Problem Solving/Skill Building** session with 34 participants was conducted at Evergreen Valley College under the guidance of Chris Barker and Susan Talbot. Participants learn to use computers for effective mastery of common math skills. They developed problem solving resources for use in lecture.

The **Exploratory** session with 20 participants was held at De Anza College with Chris Avery. Participants learned to use the computer to explore complex math concepts from Algebra II through calculus using graphical and numerical techniques. They gave weekly demonstrations to their peers. Over 50+ Exploratory activities were designed by this group for use with their classes in the following year.

Frank Soler lead the **Simulation** session at De Anza College with 10 participants. The teachers in this section ranged from grade six through college. They reviewed the theory of statistics using the computer to explore and investigate the various ideas behind the stochastic model. The teachers worked through a set a lab assignments that explored these concepts using computer simulations. They made plans to implement these ideas in their respective schools in the coming year.

Additional consultation and support was provided by Dr. James Smart of San Jose State University.

IV. The 1989 Institute

The 1989 summer program involved 8 Associates from the previous year. The Associate are key to the transition process for teachers. They provide excellent roll models for teachers trying to incorporate computer-based instruction techniques into their curriculum. The Associates managed much of the Summer Institute.

The Problem Solving/Skill Building session had 27 teachers including three associates from the previous year.

The Exploratory session involved 18 participants with four associates from the last summer.

The Simulation session had 10 members with two associates from De Anza Collége both

funded by a college grant.

Course descriptions are attached for the 1988 and 1989 sessions,

V. FUTURE PLANS

The Institute will expand to Sacramento City College under the direction of Gary Kersting and Grossmont College in San Diego under the direction of Dave Lunsford. We are currently searching for funding for summer 1990. But some form of instruction will be offered in any event.

VI. FOR INFORMATION

For further information on the Summer Institute or on any of the CAI models discussed above please contact:

Chris Avery: Chris Barker Frank Soler	De Anza College 21250 Stevens Creek Blvd. Cupertino, CA 95014 (408) 265 - 5659 or (408) 864 - 8774
Susan Talbot	Evergreen Valley College 3095 Yerba Buena Road San Jose, CA 95135 (408) 274 - 6700
Dave Lunsford	Grossmont College 8800 Grossmont College Dr. El Cajon, CA 92020 (619) 465 - 1700
Gary Kersting	Sacramento City College 3835 Freeport Blvd. Sacramento, CA 95822 (916) 449 - 7268

Mathematics 37
Basic Skills in Problem Solving

Instructors:	Susan Talbot	Phones:	257-3478
	Chris Barker		252-3493
Office:	Roble G-242		274-7900 X 6618

Course Description

This course is designed for teachers of pre-, beginning and intermediate algebra. Teachers will develop a plan to implement computer aided instruction in their classes. The focus of the course is on teaching problem solving. Instruction in basic algebraic skills will be motivated by and related to appropriate applications; it will be accomplished largely by computer lab work.

Objectives

I. Review mathematical principles in pre-, beginning and intermediate algebra and relate them to available computer software.
II. Demonstrate an understanding of the use of computer methodologies as an instructional aid in teaching basic skills.
III. Research and create a set of problems and applications that incorporate the basic skills.
IV. Develop a computer based instructional model and implementation plan for teaching problem solving in at least one pre-, beginning or intermediate algebra class during the next year.
V. Develop an evaluation plan to assess problem solving abilities and basic skill development of students in the course to be taught.

Materials

Texts/Course Objectives (from each individual's district)
Software
Notebook

Evaluation

Throughout the course, developing plans, problems and usable classroom materials will be kept in an expandable notebook. This will comprise the record of accomplishment of the stated objectives and will provide the foundation for implementation the following school year.

PROBLEM SOLVING COURSE ACTIVITIES

One of the objectives of the six week session was for each participating teacher to formulate a plan to integrate computer assisted instruction into at least one course he/she would be teaching in the 1988-89 school year. Samples of plans and what considerations they needed to address were provided.

The second major objective was for each participant to select a large number of appropriate problems, matched with course curriculum and categorized according to problem solving strategies. These were collected in a notebook provided by ICAMI.

Classroom sessions

The first hour or two of a day's three and a half hour session was spent in a classroom. Samples of software appropriate to students learning arithmetic, pre, beginning and intermediate algebra and geometry were demonstrated in class using two different projection devices, an Electro Home and a PC Viewer.

Problem solving strategies were discussed and sample problems solvable using a variety of strategies were presented. The distinction between word problems which are more appropriately labeled verbal exercises, and the types of problems focused on in this class was emphasized. In particular, the intention in choosing problems was to eliminate contrived problems whenever possible, or at least to be aware of them when choosing them for some cogent reason.

The idea that problem posing is a valuable adjunct to problem solving was of great interest. A situation or mathematical statement would be introduced and then a list of questions that could be asked about it was generated. Problem posing encourages creativity, "ownership" of the problem on the part of the poser, and deemphasizes being right or wrong in mathematics. It is also an important process at the finish of problem solving when it is appropriate to ask questions regarding the meaning of results, possible extensions to results, and so on.

Gradually more and more of the classroom portion of the summer workshop was devoted to presentations by the participants. Many used the computer and demonstrated software they liked. A myriad of problems was brought in and solved by the class, often working in cooperative groups. The presenter and the class then explored levels at which each problem could be asked, how each could be rephrased and extended or adapted. Thus problem solving was modeled by the teachers who were going to take it back to their classrooms. In the process a great variety of problems, in living color, were offered for inclusion in each participant's resource problem notebook.

Computer laboratory sessions

The second half of each day took place in the computer lab, where each person had an Apple IIe to use. At first most of the time was spent becoming familiar with software. To do this required going through each disk and doing problems or activities. The skill building programs from the Math Lab were given to each teacher as part of the Institute. For those teachers whose courses used textbooks, a major task was to match the text topics with the program menu options. It was an even greater task for teachers who had no text in their course to match curriculum topics to software. A great variety of other software was available for inspection. Of the others, two of the programs most commonly included in people's computer plans were the Geometric Presupposer by Sunburst and the Math Shop by Scholastic.

Also available in the lab were books of problems and books on problem solving which participants could use and borrow in their search and research. Teachers of the same course were encouraged to work together. The instructors acted as resource people and guides as the computer and problem solving plans took shape.

On the next pages are included samples of lab plans, problem solving activities and assignments that were developed by the ICAMI participants in 1988.

The Institute for Computer-Aided Mathematics Instruction
De Anza College

Math 162: Teacher-in-service, Exploratory Model Summer 1988

Instructor: Chris Avery 265 - 5659
Office E21b

Desired outcomes:

- Become familiar with the computer as an instructional tool both in lecture and lab
- Use a computer to review mathematical concepts from algebra through calculus
- Discover methods that allow students to discover and explore complex mathematical topics in a way that stimulate understanding and creates a desire to learn mathematics.
- Develop curriculum for the 1989 -1990 school year that deploys the numerical and graphical strengths of the computer
- Provide input that results in an improvement of computer-instructional learning models.

Materials supplied by ICAMI:

Software:
Interactive Pre-Calculus
Interactive Calculus

Written material
User's Manuals for the above software
Interactive Calculus Computer Laboratory

Suggested Reference: *The VNR Concise Encyclopedia of Mathematics* published by Van Nostrand Reinhold

Preliminary Outline: Each day will begin in S45 with lecture and demos from participants. The second part of the day will be spent in the computer lab E31. Lab time will be spent working working and designing lab assignments and CAI lecture material.

Plans, problems and classroom materials will be kept in an expandable notebook. This will comprise the record of accomplishment of the stated objectives and will provide the foundation for implementation the following school year.

The following are suggested topics. These may change according to the interests and needs of our group.

Week 1, 2 **Pre Calculus Mathematics**

Graphing: cartesian, polar, parametric, implicit,
three dimensional
zero's of functions
inverses of functions
linear equations
applications

Week 3, 4 **Differential Calculus**

Limits and recursion
asymptotes, fixed points
differentiation-ordinary, parametric and implicit
mean value theorem and approximations
tangent lines
sequences and series
applications

Week 5 **Integral Calculus**

riemann sums and area
numerical integration
Fundamental Theorem of Integral Calculus
improper integrals
applications

Week 6 Participants focus on preparation for following school year

The Institute for Computer-Aided Mathematics Instruction
De Anza College segment

Math 162: Teacher-in-service, Exploratory Model Summer 1989

Instructor	Chris Avery Office E21b	265 - 5659
Associates	Jan Espinosa	842 - 8186
	Fred Harris	272 - 2387
	Howard Jensen	255 - 9463
	George Van Buskirk	269 - 6567

Desired outcomes

- Become familiar with the computer as an instructional tool both in lecture and lab
- Use a computer to review mathematical concepts from algebra through calculus
- Discover methods that allow students to discover and explore complex mathematical topics in a way that stimulate understanding and creates a desire to learn mathematics.
- Develop curriculum for the 1989 -1990 school year that deploys the numerical and graphical strengths of the computer
- Provide input that results in an improvement of computer-instructional learning models.

Materials supplied

Software: *Interactive Pre-Calculus*
Interactive Calculus
Written material : User's Manuals for the above software
Lab Assignments as needed

Preliminary Outline

Each day will begin in S45 at 1:30 with lecture and demos from participants. The second part of the day will be spent in the computer lab E31. Lab time will be spent working working and designing lab assignments and CAI lecture material. The lab concludes at 5:00.

Plans, problems and classroom materials will be kept in an expandable notebook. This will comprise the record of accomplishment of the stated objectives and will provide the foundation for implementation the following school year.

The following are suggested topics. These may change according to the interests and needs of our group.

Exploratory Topic	**Date**	**Presenter**
Introduction	6/27	Chris Avery
Linear Equations and Inequalities	6/28	Howard Jensen
Polynomial and Rational Functions	6/29	Jan Espinosa
Holiday	7/3	
Holiday	7/4	
Implicit Relations, Inverse Functions	7/5	Fred Harris
Conic Sections	7/6	Fred Harris
Matrices and Row Reduction	7/10	Howard Jensen
Simultaneous Equations	7/11	Fred Harris
Trigonometric Functions	7/12	Jan Espinosa
Trigonometric Identities	7/13	Howard Jensen
Polar Coordinates and Equations	7/17	Jan Espinosa
Simultaneous Polar Equations	7/18	George Van Buskirk
Algebra of Functions, Absolute Value	7/19	Jan Espinosa
Exponential and Logarithmic Functions	7/20	Fred Harris
Vectors and Parametric Equations	7/24	George Van Buskirk
Sequences and Series	7/25	Chris Avery
Recursion	7/26	Chris Avery
Limits and Continuity	7/27	George Van Buskirk
Derivatives and Tangent Lines	7/31	George Van Buskirk
Applications of Extrema	8/1	Howard Jensen
Integration	8/2	Chris Avery
Open	8/3	

MATH 163
INTERACTIVE STATISTICS WITH PROBABILITY
FRANK SOLER

Goals and Objectives

For as long as 10 years (perhaps longer), NCTM, ASA, and other professional organizations have attempted to make statistical concepts and ideas more accessible to the masses. These attempts have not produced the desired results:

a. witness the dismal number of statistics courses offered at our High Schools;
b. witness the dissemination of the teaching of Statistics to peripheral departments: sociology, psychology, business, and others. The message is clear: mathematics and statistics departments are not making statistics comprehensible to the masses;
c. witness the critical shortage of competent instructors in the field of statistics.

Thus, this Summer Institute will attempt to alleviate these problems by:

a. introducing Junior High and High School teachers to the power of statistical ideas from the point of view of simulation, graphics, and computer driven interactive activities;
b. modelling the use of the computer as an aid in presenting complex statistical topics;
c. advancing the philosophy that a statistics and probability course is highly stochastic and not deterministic;
d. creating the opportunity to allow for the planning of a semester or year long curriculum in statistics using the computer as the basic tool;
e. exploring ways of making statistical ideas more appealing and reachable to students.

Daily activities

1:30 PM - 2:45 PM : Instructor leads presentation/discussion
2:45 PM - 3:30 PM : Participants lead presentation/discussion:
- a. discuss selected topics with the use of the computer;
- b. work selected problems from textbook /labs on the computer.

3:30 PM - 5:00 PM : Lab time:
- a. complete lab assignments;
- b. pursue book exercises where computer used is called for;
- c. correlate curricula to fit school/district needs;
- d. design of new lab activities;
- e. individual or group consultations about pedagogical issues of interest.

Evaluation of participants

a. completion of all 34 lab assignments.
b. generation of implementation plan for academic year 1988-1989:
   i. syllabus of material to be covered;
   ii. pace and content;
   iii. evaluation plan.
c. contribution to discussion/presentation.

Materials

a. Interactive Statistics with Probability; Avery and Soler, 1988.
b. Computer Lab for Statistics and Probability (diskette); Avery and Soler.
c. Appropriate materials from participants' school/district.
d. Reading list.

ERIC Clearinghouse for
Junior Colleges